MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

Vol. 51, No. 5.
W. B. No. 836.

MAY, 1924.

Closed July 3, 1924.
Issued August 2, 1924.

THE OCCURRENCE OF HAIL

Editor's Note.—In response to the demand for more specific data on the occurrence of hail in the United States, the Weather Bureau began in the April number of this Review the publication of reports on the occurrence of hailstorms as observed by its regular and cooperative observers, numbering approximately 5,200. Cooperative observers report directly to the Weather Bureau officials in charge of the several section centers and these officials in turn transmit the reports to the Central Office in Washington, D. C. The reports are incorporated in the table which hitherto has borne the title "Severe Local Storms." That table will be found on pages 282–284 of this Review, and it will appear in approximately the same position hereafter.

ASCENSIONAL RATE OF PILOT BALLOONS[1]

629.132.1 : 551.55

By William C. Haines, Meteorologist

(Weather Bureau, Washington, May 6, 1924)

Pilot balloons furnish us with an efficient and economical as well as a fairly accurate means of determining the direction and velocity of the wind in the free air. The two-theodolite method, when used in connection with a base line of 2,500 meters or more in length and well chosen with respect to the direction of the wind, will give results as accurate as the readings of the theodolites. However, in exceptionally long observations, an hour or more in length, or when the balloon is moving in the vicinity of the direction of the base line, the results are not so satisfactory. In either case the angles of the triangle become so small that a slight error in the reading of the angles makes a considerable error in the computed distance and altitude of the balloon, and therefore an error in the resulting wind velocity and direction.

In general, the single-theodolite method is better adapted for the procurement of free-air data than is the double-theodolite method, but the accuracy of its results is dependent upon the accuracy with which the altitude of the balloon is known. The Meteorological Section, Signal Corps, carried on during the war an extended investigation in order to develop a formula that would give the ascensional rate of balloons.[2] As a result of these studies, the following empirical formula which is a modification of the Dines' formula was developed and adopted as the one giving the best results:

$$V=71\left(\frac{l^3}{L^2}\right)^{.208} \tag{1}$$

in which V is the rate of ascent in m./min., l is the free lift or ascensional force in grams, and L is the free lift plus the weight of the balloon. This formula was based on about 1,000 two-theodolite observations taken in all seasons of the year and at all times of the day. After the war a slight revision was made as the result of further study and the inclusion of additional data secured by the Weather Bureau and the Signal Corps. The revision consisted of a change in the constant from 71 to 72 and of the introduction of small additive corrections for the first five minutes of ascent.[3] The Weather Bureau has used this revised formula since April, 1921.

[1] Presented before American Meteorological Society at Washington, April 30, 1924.
[2] Sherry, B. J. and Waterman, A. T., The military Mereorological Service in the United States during the War. Mo. Weather Rev. April, 1919. 47: 218.
[3] Sherry, B. J. The Rate of Ascent of Pilot Balloons. Mo. Weather Rev. Dec. 1920, 48: 692-694.

The two-theodolite work has been continued by the Weather Bureau at the various aerological stations in order to verify the ascensional rate formula in use; also to determine to what extent the ascensional rate is affected by convection, and to study the behavior of balloons at high altitudes. The first step taken toward this end was to standardize the ascensional rate of balloons. Since the latter part of 1921, the balloons have been inflated by an automatic weighing device to give an ascensional rate of 180 m./min in both single and double theodolite observations. The balloons used are 6 inch rubber weighing from 25 to 35 grams, and when inflated are approximately 60 centimeters in diameter. The a. m. observations are ordinarily taken between 7 and 8 and the p. m. between 3 and 4, 75th meridian time.

This paper is based on the study of all two-theodolite observations taken by the Weather Bureau since the standardized ascensional rate was adopted, or on more than 800 observations of 10 minutes or more in length. The following method was employed to determine the actual rate of ascent of the balloons at successive altitudes: In order to show to what height convection influences the ascensional rate, the average rate of ascent for each minute for the first 10 minutes was obtained. From altitudes of 2,000 to 11,000 meters, the average rates were obtained for four-minute periods immediately above each thousand-meter level, and above 11,000 meters the average rates for five-minute periods were taken. The data were treated in this manner to get the ascensional rate through the various strata of air from the surface to the highest altitude, independent of convection which might have affected the ascensional rate in the lower levels. The a. m. data, p. m. data, and a. m. and p. m. data combined, were considered separately. The means were plotted as ordinates and the altitudes as abscissae, and empirical curves were fitted to the points by the method of least squares. It was found that the points were best fitted by two equations of the form of

$$R=ah^2+bh+c \tag{2}$$

in which R is the rate of ascent per minute, h is the altitude in meters and a, b and c are constants. The original data to which the curves were fitted are given in Table 1.